is a fair sample of the rainfall over a large region in his neighborhood—which is often far from being true—he may compute the total quantity of water that falls upon any field or any drainage basin or river watershed. From this he gets a crude idea of the rainfall needed in order to perfect his crops, but it is a very crude idea because the crop only uses an exceedingly small percentage of this rainfall, the rest being partly absorbed in the ground and stored away for future dry seasons, partly returned to the air by evaporation, and mostly flowing off to the river by surface drainage. The total quantity needed for the ripening of a crop, when the water is carefully conserved, is a matter that is being determined by the experience of those who are farming by irrigation, and this style of farming which is common enough in our dry regions promises to become of fundamental importance for the whole country. There is no section of the United States that is not liable to droughts severe enough to affect the crops. A farm that covers a large area may in a dry season produce enough on the lowlands to counterbalance the loss of the crop on the uplands, but a small farmer can not afford to thus risk the loss of his whole crop, and must, therefore, be ready to raise his crops by artificial irrigation. But to irrigate requires either a windmill to pump up water from wells and reservoirs, or else a pond, ditch, or reservoir on some higher ground. In any case one must know what amount of water he needs, how large a reservoir must be built, and how powerful a windmill is required to do the work of pumping. To this end the ordinary meteorological method of measuring rainfall must be supplemented by a table of cubic measures.

An acre of ground covers 43,560 square feet, therefore 12 inches of rainfall means 43,560 cubic feet of water per acre. This may be converted into gallons or into pounds weight, if we choose, by the following considerations; one gallon contains 277.274 cubic inches, there are, therefore, 6.2321 gallons in a cubic foot; a gallon of pure water at 62° F., as weighed in the atmosphere, weighs 10 pounds. It will, however, be simpler for our present purposes to measure the water in cubic feet. The quantity of water per acre for a given depth of rainfall is expressed in cubic feet in the following table:

Rainfall (depth).	Equivalent per acre.
Inches.	*Cubic feet.*
0.10	363
0.50	1,815
1.00	3,630
2.00	7,260
3.00	10,890
4.00	14,520
5.00	18,150
6.00	21,780
7.00	25,410
8.00	29,040
9.00	32,670
10.00	36,300
11.00	39,930
12.00	43,560

In gauging the amount of water in streams the unit of measurement is a rate of flow equivalent to 1 cubic foot of water per second of time, and the carrying capacity of a ditch must be expressed in these units.

Another standard of measurement is the so-called miner's inch, but this is quite an indefinite term, inasmuch as the flow of water corresponding to a miner's inch varies with the structure of the gate or sluiceway and the construction of the aperture through which the water flows, so that actual experiment has shown that the miner's inch, as used in Colorado, is equivalent to 11.7 gallons of water per minute, while that used in California is 9 gallons per minute.

MELTING SNOW AND RIVER FLOODS.

The floods in the Mississippi and Missouri are often attributed to the influence of melting snow in the Rocky Mountain Region, but this is really only a small item in comparison with the rainfall in the lower Missouri, the upper Mississippi, the Arkansas, and the Ohio watersheds. The recent great flood in the Mississippi was demonstrably caused by a combination of floods due to such rainfall. In connection with the experimental study of the development of agriculture by irrigation, the question of water supply, whether it comes from artesian wells or rain, from rivers or from melted snow, has been especially studied at the Agricultural Experiment Station of the State Agricultural College at Fort Collins, on the Cache a la Poudre River. In the course of this investigation measurements of the discharge, expressed in cubic feet per second, were made at stations on the Poudre and the Platte Rivers, after shutting off all the head gates leading into the irrigation ditches. Full accounts of the studies that have been made in connection with irrigation have been published in the bulletins of the Experiment Station, Nos. 9, 13, 16, 22, 26, 27, 33. From the last bulletin, dated January, 1896, it appears that the first gauging of the Poudre River was made in October, 1885, and the discharges in successive years at the gauging station, in cubic feet per second, were as follows:

	Cubic feet per second.	Rainfall since Jan. 1.	Rainfall within 3 weeks.
		Inches.	*Inch.*
1. 1885, October 12–15	127.609	....	....
2. 1889, October 14–17	68.723	11.22	0.34
3. 1890, October 16–18	80.776	13.12	0.70
4. 1891, October 23–30	97.58	14.62	0.19
4*a*. 1891, November 3	107.01	4.62	0.19
5. 1892, March 10–12	65.02	2.72	0.83
6. 1892, October 5–8	62.92	13.94	0.00
7. 1893, November 9–11	52.47	6.28	0.00
8. 1894, March 13–15	99.21	0.85	0.00
9. 1894, August 20–23	268.07	9.25	0.08
10. 1895, October 9–14	66.47	16.60	0.00

The measurements made below the gauging station show that the water which passes any point is not only that flowing in the channel just above, but is increased by an additional amount due to seepage, which is very large in the sandy soil of the Poudre and Platte valleys. In the spring time this seepage largely represents the water that has settled into the surrounding soil from melted snow, while in the summer time it results from drainage and rainfall. The discharge of the river proper at the Fort Collins gauging station, which is in the canyon about 12 miles above the college and above the head gates of all the principal canals, might be expected, therefore, to increase with the melting of snow on the higher lands to the westward, but the actual gaugings seem to indicate that the snow water, which permeates the soil very slowly, is not so important as the rainfall of the spring and summer months. The seepage is greatly favored by the warmth of the soil, since heat decreases the viscosity of water. This effect has been studied by Professor Carpenter and found to be appreciable. The average discharge at the gauging station, as deduced from records of a number of years, varying between three and twelve for the different months, is as follows:

	Cubic feet per second.		Cubic feet per second.
January	110	July	1,018
February	83	August	362
March	70	September	173
April	237	October	136
May	1,245	November	81
June	2,017	December	74

In continuation of these normal values the following items of daily discharge are quoted from the weekly Poudre River bulletins that are now issued by Prof. L. G. Carpenter of the experiment station. His bulletins, Nos. 1 and 4, for the week April 14–20 and May 5–11, are the only ones at hand, but will illustrate the slight importance of melted snow as compared with rain.

Up to April 14 the river remained low; the discharge was a little over 100 cubic feet per second. The warm, clear days of Friday, Saturday, and Sunday caused a more rapid melting of snow and an increased volume in the river on Sunday, Monday, and Tuesday. The average for Monday, April 20, was unusually large for this season. The reports indicate that there is little snow left on the mountains below an elevation of 8,000 feet. The amount of snow has been greater than usual, and the total amount of water received (namely at the gauging station) will be greater than for a number of years. Nevertheless there will be the usual scarcity late in the season.

From the bulletin for May 5–11, we quote:

The week having proved a warm one with the temperature of 70° and above, each day at the Agricultural College, and 55°, or over, at elevations of 9,000 feet, the melting of the low-lying snow has proceeded rapidly and the river has exceeded the flow for the corresponding week even in the exceptional year of 1885. The self-recording instruments show that the high water due to the melting of snow at midday on the mountains now reaches the gauging station in the canyon about 5 a. m. of the subsequent day.

The following averages are copied from these bulletins:

Discharge in cubic feet per second of the Poudre River.

Date.	1897.		Average for 1896.	Average, 10 years.
	Daily average.	Daily maximum.		
Wednesday, April 14	128	138	93	145
Thursday, April 15	158	184	124	155
Friday, April 16	173	180	140	160
Saturday, April 17	214	233	145	169
Sunday, April 18	247	364	120	208
Monday, April 19	470	571	109	220
Tuesday, April 20	450	480	114	239
Average for week	270	....	120	185
Wednesday, May 5	1,163	1,240	522	612
Thursday, May 6	1,251	1,321	708	686
Friday, May 7	1,437	1,502	946	748
Saturday, May 8	1,486	1,579	1,125	821
Sunday, May 9	1,472	1,602	....	916
Monday, May 10	1,439	1,546	....	1,000
Tuesday, May 11	1,458	1,568	....	930
Average for week	1,385	....	....	816

Averages for the corresponding weeks in previous years.

Year.	April 14–20.	May 5–11.	Year.	April 14–20.	May 5–11.
1884	146	911	1891	109	143
1885	204	1,358	1892	....	....
1886	....	773	1893	....	....
1887	294	....	1894	....	977
1888	136	354	1895	344	962
1889	93	283	1896	121	*825
1890	157	722	1897	270	1,385

* From the average for 14 days.

SNOWFALL IN COLORADO.

In connection with the preceding subject the most accurate estimates of the amount of snowfall become important. Mr. F. H. Brandenburg of the Weather Bureau, section director for Colorado, on March 10, issued a special snowfall report for that State. In addition to the data furnished by ninety voluntary observers he has received special snowfall returns from about two hundred and fifty special correspondents. According to these over the upper drainage basin of the Arkansas, in general, the snowfall has been greater than last year, and in many cases greater than for many years and large quantities of snow water will be held in reserve. Over the South Platte drainage area much more snow than usual, and the heavy snow slides in the timber will cause it to remain longer than usual. On the Continental Divide, over Clear Creek and Gilpin counties, the fall has been less than the average. Over the upper Rio Grande Basin snowfall was comparatively light, but lower down there was a marked excess. Over the Gunnison River watershed snowfall has been deficient. On the average for the whole eastern slope of Colorado the available water supply will be above the normal.

EVAPORATION AT FORT COLLINS, COLO.

In the Annual Reports of the experiment station at Fort Collins for 1889, 1890, and 1891 (which is the last at hand) details are given as to the measurements and experiments made in order to determine the amount of evaporation, in open air tanks, as well as in the running water of canals. The evaporation from tanks in the sunshine must depend upon the wind at the surface of the water, on the temperature of the water surface, and on the dryness of the air that blows over it; in place of exact measurements of these data approximate values had to be used. The report of Professor Carpenter states that the evaporation expressed in inches of depth of water in twenty-four hours may be computed by the following formula:

$$E = 0.39\ (P - p)\ (1 + 0.02\ W)$$

where P is the vapor tension corresponding to the temperature of the surface of the water; p is the vapor tension actually observed in the free air; w is the movement of the wind in miles, in twenty-four hours, at the surface of the water. In computing daily and monthly averages the mean temperature of the water surface is assumed to be the mean between the observations made at 7 a. m. and 7 p. m. The wind was measured by means of the anemometer on a tower a hundred feet distant. The moisture present in the air was deduced from dry and wet bulb thermometers. The coefficients 0.39 and 0.02 give a computed evaporation that is generally within 10 per cent, and on the average of the year is within 2 per cent of the measured evaporation. During 1890 the average daily evaporation from a 3-foot tank sunk in the ground was 0.15 inch. During 1891 the daily evaporation ranged between 0.18 in July and 0.02 in December.

HAIL AND A RAIN GAUGE FOR ITS MEASUREMENT.

The voluntary observer at Beaver in Oklahoma is quoted in the April report of the Oklahoma section as follows:

On the 27th heavy hailstorm came directly from the west, rain lasted twenty minutes, and fully an inch of hail fell; the ground appeared covered with snow. Hail drifted in places to 6 inches deep; 0.70 inch of rain was in the gauge, but no hail, and I estimated the melted hail at 0.30. Hail certainly all bounded out of the gauge as examination was made immediately after the rain ceased.

The difficulty of securing an accurate record of rainfall has led to several improvements in the construction of the rain gauge, the most important of which was the shielded gauge described by Prof. Joseph Henry as early as 1853, and the other form of shielded gauge devised by Professor Nipher in 1878. These shields are intended to protect the gauge from the loss of rainfall by the action of the wind at the mouth of the gauge. Very nearly the same protection against the wind results from the use of the protected gauge introduced by Boernstein and favorably reported upon by Wild and Herrmann.

Another source of error is due to the spattering of raindrops that are broken up into small rebounding particles by striking the ground. The spattering slightly increases the catch of the gauge, whereas the wind effect diminishes the catch to a very appreciable and sometimes a very large extent. A third source of trouble is that brought to mind by the above quotation from the Oklahoma report. Not only do the elastic hailstones bound out of the gauge, but large drops of water may easily do the same if the gauge is improperly constructed; if the drops do not bound outward as a whole, they may still break up and be partly lost as outward spatter. The remedy for this must consist in setting